NEXT GENERATION SCIENCE STANDARDS

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Happy Summer Solstice!

- Overview (Guiding Framework)
- Structural Format
- Physical Science Draft Standards

THE FRAMEWORK

- The National Research Council developed a guiding framework for the development of the Next Generation Science Standards (NGSS)
  - vision for what it means to be proficient in science
  - based on view of science as body of knowledge and an evidence-based model and theory building endeavor; continually expanding, refining and revising knowledge.

RECENT NEWS (JUNE 19, 2012)

- **Results on new component of Nation's Report Card (NAEP) released**
  - focused on hands-on, interactive and virtual labs
- **Overall, students could conduct the experiments but were not as skilled in using their data to justify conclusions or writing reports.**
  - In one example, 93% of fourth graders got the right answer in a science experiment, but only 32% could use the evidence from the experiment to justify their answer.

"students overall across all the task and across all grade levels were challenged by the parts of the test that required them to consider more than one variable at a time or if they had to make strategic decisions about how to collect the data."
Jack Buckley - National Center for Education Statistics Commissioner

"Students could select correct conclusions, but didn't do so well when we asked them to explain their conclusions using the evidence from the data tables."
Jack Buckley - National Center for Education Statistics Commissioner

PUTTING OUR TEACHING JOBS IN PERSPECTIVE

THE FRAMEWORK

- **Three dimensions combined for each standard**
  - Dimension 1 – Practices
    - describes behaviors that scientists engage in and the key set of engineering practices that engineers use
  - Dimension 2 – Crosscutting Concepts
    - have application across all domains of science
    - patterns, cause and effect, scale, systems, energy and matter, structure and function, stability and change
  - Dimension 3 – Disciplinary Core Ideas
    - help focus curriculum, instruction and assessments on most important aspects of science
    - physical sciences, life sciences, earth and space sciences, engineering, technology and applications of science

Performance Standards

Crosscutting Concepts

Science and Engineering Practices

Disciplinary Core Ideas

HS.PS-FM Forces and Motion

HS.PS-FM Forces and Motion

Students who demonstrate understanding can:

a. **Plan and carry out investigations to show that the algebraic formulation of Newton's second law of motion accurately predicts the relationship between the net force on macroscopic objects, their mass, and acceleration and the resulting change in motion.** [Assessment Boundary: Restricted to one- and two-dimensional motion and does not include rotational motion. Does not apply in the case of subatomic scales or for speeds close to the speed of light. Calculations restricted to macroscopic objects moving at non-relativistic speeds.]

b. **Generate and analyze data to support the claim that the total momentum of a closed system of objects before an interaction is the same as the total momentum of the system of objects after an interaction.** [Clarification Statement: Conservation of momentum is the focus.]

c. **Use algebraic equations to predict the velocities of objects after an interaction when the masses and velocities of objects before the interaction are known.** [Assessment Boundary: Restricted to macroscopic interactions and only two objects moving in one or two dimensions.]

d. **Design and evaluate devices that minimize the force on a macroscopic object during a collision.**

e. **Construct a scientific argument supporting the claim that the predictability of changes within systems can be understood by defining the forces and changes in momentum both inside and outside the system.** [Assessment Boundary: Restricted to macroscopic interactions.]

f. **Communicate arguments to support claims that Newton's laws of motion apply to macroscopic objects but not to objects at the subatomic scales or speeds close to the speed of light.** [Assessment Boundary: No details of quantum physics or relativity are included.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education:*

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that build, test, and revise conceptual, mathematical, physical and empirical models.

- Plan and carry out investigations individually and collaboratively and test designs as part of building and revising models, explaining phenomena, or testing solutions to problems. Consider possible confounding variables or effects, and ensure that the investigation's design has controlled for them. (a)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims. (b)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical expressions to represent phenomena or design solutions in order to solve algebraically for desired quantities. (c)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Apply scientific knowledge to solve design problems by taking into account possible unanticipated effects. (d)
- Evaluate the claims, evidence, and reasoning of currently accepted explanations or solutions as a basis for the merits of the arguments. (d)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. Arguments may also come from current scientific or historical episodes in science.

- Evaluate the claims, evidence, and reasoning of currently accepted explanations or solutions as a basis for the merits of the arguments. (e),(f)

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Newton's second law accurately predicts changes in the motion of macroscopic objects, but it requires revision for subatomic scales or for speeds close to the speed of light. (a),(e),(f)
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (b)
- In any system, total momentum is always conserved. (b),(c)
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (c),(d),(e)

PS2.C: Stability and Instability in Physical Systems

- Systems often change in predictable ways; understanding the forces that drive the transformations and cycles within a system, as well as the forces imposed on the system from outside, helps predict its behavior under a variety of conditions. (d),(e)

Crosscutting Concepts

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects. (a),(c),(d)

Systems and System Models

When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (b),(e)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications. Engineers continuously modify these systems to increase benefits while decreasing costs and risks. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (d)

PHYSICAL SCIENCE (PHYSICS) DRAFT STANDARDS…

(EMPHASIS ON DRAFT)

HS PHYSICAL SCIENCE – FORCES AND MOTION

Students who demonstrate understanding can:

a. Plan and carry out investigations to show that the algebraic formulation of Newtons second law of motion accurately predicts the relationship between the net force on macroscopic objects, their mass, and acceleration and the resulting change in motion.

b. Generate and analyze data to support the claim that the total momentum of a closed system of objects before an interaction is the same as the total momentum of the system of objects after an interaction.

c. Use algebraic equations to predict velocities of objects after an interaction when the masses and velocities of objects before the interaction are known.

d. Design and evaluate devices that minimize force on a macroscopic object during a collision.

e. Construct a scientific argument supporting the claim that the predictability of changes within systems can be understood by defining the forces and changes in momentum both inside and outside the system.

f. Communicate arguments to support claims that Newtons laws of motion apply to macroscopic objects but not to objects at the subatomic scales or speeds close to the speed of light.

HS PHYSICAL SCIENCE – INTERACTIONS OF FORCES

Students who demonstrate understanding can:

a. Use mathematical expressions to determine the relationship between the variables in Newtons Law of Gravitation and Coulombs Law, and use these to predict the electrostatic and gravitational forces between objects.

b. Use models to demonstrate that electric forces at the atomic scale affect and determine the structure, properties (including contact forces), and transformations of matter.

c. Plan and carry out investigations to demonstrate the claim that magnets, electric currents, or changing electric fields cause magnetic fields and electric charges or changing magnetic fields cause electric fields.

d. Obtain, evaluate, and communicate information to show that strong and weak nuclear interactions inside atomic nuclei determine which nuclear isotopes are stable, and that the pattern of decay of an unstable nucleus can often be predicted.

e. Obtain, evaluate, and communicate information to show how scientists and engineers take advantage of the effects of electrical and magnetic forces in materials to design new devices and materials through a process of research and development.

HS PHYSICAL SCIENCE – FORCES AND ENERGY

Students who demonstrate understanding can:

a. Plan and carry out investigations in which a force field is mapped to provide evidence that forces can transmit energy across a distance.

b. Develop arguments to support the claim that when objects interact at a distance, the energy stored in the field changes as the objects change relative motion.

c. Evaluate natural and designed systems where there is an exchange of energy between objects and fields and characterize how the energy is exchanged.

HS PHYSICAL SCIENCE – ENERGY

Students who demonstrate understanding can:

a. Construct and defend models and mathematical representations that show that over time the total energy within an isolated system is constant, including the motion and interactions of matter and radiation within the system.

b. Identify problems and suggest design solutions to optimize the energy transfer into and out of a system.

c. Analyze data to support claims that closed systems move toward more uniform energy distribution.

d. Design a solution to minimize or slow a systems inclination to degrade to identify the effects on the flow of the energy in the system.

e. Construct models to show that energy is transformed and transferred within and between living organisms.

f. Construct models to represent and explain that all forms of energy can be viewed as either the movement of particles or energy stored in fields.

g. Construct representations that show that some forms of energy may be best understood at the molecular or atomic scale.

h. Design, build, and evaluate devices that convert one form of energy into another form of energy.

HS PHYSICAL SCIENCE – WAVES

Students who demonstrate understanding can:

a. Plan and carry out investigations to determine the mathematical relationships among wave speed, frequency, and wavelength and how they are affected by the medium through which the wave travels.

b. Carry out an investigation to describe a boundary between two media that affects the reflection, refraction, and transmission of waves crossing the boundary.

c. Investigate the patterns created when waves of different frequencies combine and explain how these patterns are used to encode and transmit information.

d. Use drawings, physical replicas, or computer simulation models to explain that resonance occurs when waves add up in phase in a structure, and that structures have a unique frequency at which resonance occurs.

HS PHYSICAL SCIENCE – ELECTROMAGNETIC RADIATION

Students who demonstrate understanding can:

a. Use arguments to support the claim that electromagnetic radiation can be described using both a wave model and a particle model, and determine which model provides a better explanation of phenomena.

b. Obtain, evaluate, and communicate scientific literature to show that all electromagnetic radiation travels through a vacuum at the same speed(called the speed of light).

c. Obtain, evaluate, and communicate scientific literature about the effects different wavelengths of electromagnetic radiation have on matter when the matter absorbs it.

d. Analyze and interpret data of both atomic emission and absorption spectra of different samples to make claims about the presence of certain elements in the sample.

e. Construct an explanation of how photovoltaic materials work using the particle model of light, and describe their application in everyday devices.

f. Obtain, evaluate and communicate scientific literature about the differences and similarities between analog and digital representations of information to describe the relative advantages and disadvantages.

g. Construct explanations for why the wavelengths of an electromagnetic wave determines its use for certain applications.

CURRENT SOUTH DAKOTA VS NGSS STANDARDS

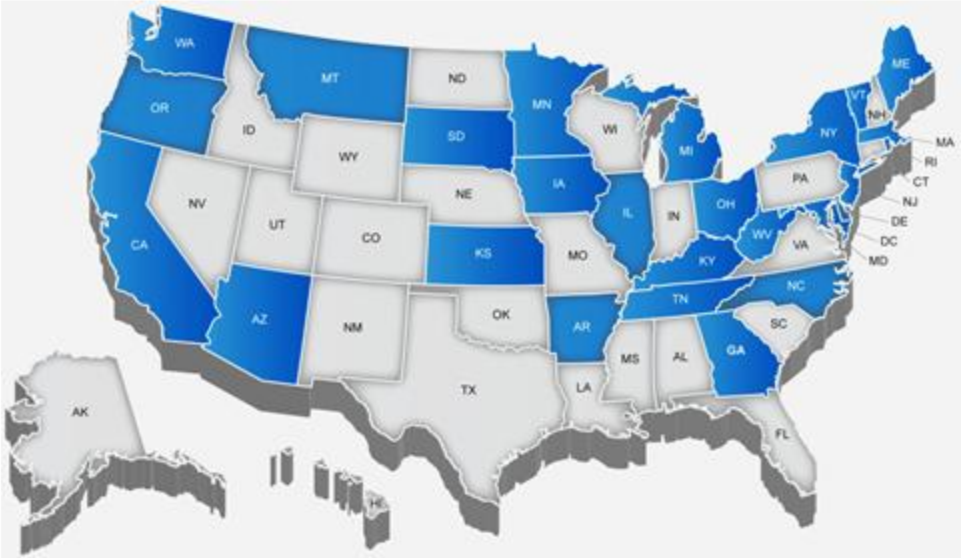
- Currently do not have Basic, Proficient, Advanced levels
- Core performance descriptors similar to NGSS performance standards
  - Performance standards broader and more focused on process of science and engineering
- No specific course/grade level definitions yet for NGSS
- General assessment limit recommendations included with NGSS but specific assessment not yet clearly defined at national or state level

THE NGSS DEVELOPMENT PROCESS

DEVELOPMENT PROCESS

LEAD STATE PARTNERS

South Dakota is one of 26 states reviewing and providing input to the national writing team.



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